FORM PTO-1390 (REV 10-94) U S DEPARTMENT OF COMMERCE PATENT AND TRADEMARK OFFICE

TRANSMITTAL LETTER TO THE UNITED STATES DESIGNATED/ELECTED OFFICE (DO/EO/US) CONCERNING A FILING UNDER 35 U.S.C. 371

ATTORNEY'S DOCKET NUMBER: 616.99USWO

U S APPLICATION NO (If known, see 37 C F R 1 5): UNKNOWN 10/019390

INTERNATIONAL APPLICATION NO.	INTERNATIONAL FILING DATE	PRIORITY DATE CLAIMED
PCT/EP00/06450	JULY 7, 2000	JULY 29, 1999

TITLE OF INVENTION

COOLING SYSTEM FOR FUEL CELLS

APPLICANT(S) FOR DO/EO/US

THOM, Frank

Applicant herewith submits to the United States Designated/Elected Office (DO/EO/US) the following items and other information:

1. [X] This is a **FIRST** submission of items concerning a filing under 35 U.S.C. 371.
2. [ ] This is a **SECOND** or **SUBSEQUENT** submission of items concerning a filing under 35 U.S.C. 371.
3. [X] This express request to begin national examination procedures (35 U.S.C. 371(f)) at any time rather than delay examination until the expiration of the applicable time limit set in 35 U.S.C. 371(b) and PCT Articles 22 and 39(l).
4. [X] A proper Demand for International Preliminary Examination was made by the 19th month from the earliest claimed priority date.

5. [X] A copy of the International Application as filed (35 U.S.C. 371(c)(2))
   a. [X] is transmitted herewith (required only if not transmitted by the International Bureau).
   b. [X] has been transmitted by the International Bureau.
   c. [ ] is not required, as the application was filed in the United States Receiving Office (RO/US)
6. [ ] A translation of the International Application into English (35 U.S.C. 371(c)(2)).

7. [X] Amendments to the claims of the International Application under PCT Article 19 (35 U.S.C. 371(c)(3))
   a. [ ] are transmitted herewith (required only if not transmitted by the International Bureau).
   b. [ ] have been transmitted by the International Bureau.
   c. [ ] have not been made; however, the time limit for making such amendments has NOT expired.
   d. [X] have not been made and will not be made.

8. [ ] A translation of the amendments to the claims under PCT Article 19 (35 U.S.C. 371(c)(3)).

9. [X] An unsigned oath or declaration of the inventor(s) (35 U.S.C. 371 (c)(4)).

10. [ ] A translation of the annexes to the International Preliminary Examination Report under PCT Article 36 (35 U.S.C. 371(c)(5)).

Items 11. to 16. below concern document(s) or information included:

11. [ ] An Information Disclosure Statement under 37 CFR 1.97 and 1.98.
12. [ ] An assignment document for recording. A separate cover sheet in compliance with 37 CFR 3.28 and 3.31 is included.

13. [X] A FIRST preliminary amendment.
    [ ] A SECOND of SUBSEQUENT preliminary amendment.

14. [ ] A substitute specification.

15. [ ] A change of power of attorney and/or address letter.

16. [x] Other items or information: PCT/EP00/06450; PCT/IPEA/210; PCT/IPEA/409; Preliminary Amendment; Abstract

531 Rec'd PCT/PT 28 DEC 2001

U.S. APPLICATION NO (If known, see 37 C F R 1 5)	INTERNATIONAL APPLICATION NO	ATTORNEY'S DOCKET NUMBER
UNKNOWN 10/01939	PCT/EP00/06450	616.99USWO

17. [X] The following fees are submitted:

CALCULATIONS PTO USE ONLY

BASIC NATIONAL FEE (37 CFR 1.492(a) (1)-(5)):

Search Report has been prepared by the EPO or JPO **$890.00**

International preliminary examination fee paid to USPTO (37 CFR 1.492(a)(1)) **$710.00**

No international preliminary examination fee paid to USPTO (37 CFR 1.482) but international search fee paid to USPTO (37 CFR 1.445(a)(2)) **$740.00**

Neither international preliminary examination fee (37 CFR 1.482) nor international search fee (37 CFR 1.445(a)(3)) paid to USPTO **$1040.00**

International preliminary examination fee paid to USPTO (37 CFR 1.482) and all claims satisfied provisions of PCT Article 33(2)-(4) **$100.00**

ENTER APPROPRIATE BASIC FEE AMOUNT =				**$890.00**	
Surcharge of **$130.00** for furnishing the oath or declaration later than [ ] 20 [ ] 30 months from the earliest claimed priority date (37 CFR 1.492(e)).				**$0**	
CLAIMS	NUMBER FILED		NUMBER EXTRA	RATE	
Total claims	6	-20 =	0	X **$18.00**	**$0**
Independent claims	3	-3 =	0	X **$84.00**	**$0**
MULTIPLE DEPENDENT CLAIM(S) (if applicable)				+ **$260.00**	**$0**
TOTAL OF ABOVE CALCULATIONS =					**$890.00**
Reduction by 1/2 for filing by small entity, if applicable. Small entity status is claimed pursuant to 37 CFR 1.27					**$0**
SUBTOTAL =					**$890.00**
Processing fee of **$130.00** for furnishing the English translation later than [ ] 20 [ ] 30 months from the earliest claimed priority date (37 CFR 1.492(f).				+	**$0**
TOTAL NATIONAL FEE =					**$890.00**
Fee for recording the enclosed assignment (37 CFR 1.21(h)). The assignment must be accompanied by an appropriate cover sheet (37 CFR 3.28, 3.31). $40.00 per property				+	**$0**
TOTAL FEES ENCLOSED =					**$890.00**
				Amount to be: refunded	**$0**
				charged	**$0**

a. [X] Check(s) in the amount of $890.00 to cover the above fees is enclosed.

b. [ ] Please charge my Deposit Account No. _____ in the amount of $ _____ to cover the above fees. A duplicate copy of this sheet is enclosed.

c. [X] The Commissioner is hereby authorized to charge any additional fees which may be required, or credit any overpayment to Deposit Account No. 13-2725.

NOTE: Where an appropriate time limit under 37 CFR 1.494 or 1.495 has not been met, a petition to revive (37 CFR 1.137(a) or (b)) must be filed and granted to restore the application to pending status.

SEND ALL CORRESPONDENCE TO
John J. Gresens
MERCHANT & GOULD
P.O. Box 2903
Minneapolis, MN 55402-0903

SIGNATURE: John J. Gresens

NAME: John J. Gresens

REGISTRATION NUMBER: 33,112

S/N unknown

PATENT

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

Applicant:	Thom, Frank	Docket No.:	616.99USWO
Serial No.:	unknown	Filed:	concurrent herewith
Int'l Appln No.:	PCTEP0006450	Int'l Filing Date:	July 7, 2000
Title:	COOLING SYSTEM FOR FUEL CELLS		

CERTIFICATE UNDER 37 CFR 1.10
'Express Mail' mailing label number: EL669944142US
Date of Deposit: December 28, 2001
I hereby certify that this paper or fee is being deposited with the United States Postal Service 'Express Mail Post Office To Addressee' service under 37 CFR 1.10 and is addressed to the Commissioner for Patents, Washington, D.C. 20231.

By: _____
Name: Chris Stordahl

PRELIMINARY AMENDMENT

Box PCT
Assistant Commissioner for Patents
Washington, D. C. 20231

Dear Sir:

In connection with the above-identified application filed herewith, please enter the following preliminary amendment:

IN THE ABSTRACT

Insert the attached Abstract page into the application as the last page thereof.

IN THE SPECIFICATION

A courtesy copy of the present specification is enclosed herewith. However, the World Intellectual Property Office (WIPO) copy should be relied upon if it is already in the U.S. Patent Office.

REMARKS

A new abstract page is supplied to conform to that appearing on the publication page of the WIPO application, but the new Abstract is typed on a separate page as required by U.S. practice.

Applicants respectfully request that the preliminary amendment described herein be entered into the record prior to calculation of the filing fee and prior to examination and consideration of the above-identified application.

If a telephone conference would be helpful in resolving any issues concerning this communication, please contact Applicants' primary attorney-of record, John J. Gresens (Reg. No. 33,112), at (612) 371.5265.

Respectfully submitted,

MERCHANT & GOULD P.C.
Post Office Box 2903
Minneapolis, Minnesota 55402-0903
(612) 332-5300

Dated: December 28, 2001

By ______________________
John J. Gresens
Reg. No. 33,112

JJG/rw

Rec'd PCT/PTO 01 MAR 2002

S/N 10/019390 PATENT

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

Applicant:	Thom, Frank	Docket No.:	616.99USWO
Serial No.:	10/019390	Filed:	December 28, 2001
Int'l Appln No.:	PCTEP0006450	Int'l Filing Date:	July 7, 2000
Title:	COOLING SYSTEM FOR FUEL CELLS		

CERTIFICATE UNDER 37 CFR 1.10
'Express Mail' mailing label number: EV072823457US
Date of Deposit: March 1, 2002
I hereby certify that this paper or fee is being deposited with the United States Postal Service 'Express Mail Post Office To Addressee' service under 37 CFR 1.10 on the date indicated above and is addressed to the Commissioner of Patents and Trademarks, Washington, D.C. 20231.

By: Chris Stordahl

10019390.030102

PRELIMINARY AMENDMENT

Box PCT
Assistant Commissioner for Patents
Washington, D. C. 20231

Dear Sir:

In connection with the above-identified application filed herewith, please enter the following preliminary amendment.

The present application was filed in the GERMAN language. Applicant now supplies the English translation of the application and the verified English translation of the specification are supplied herewith.

IN THE CLAIMS

Please amend the claims as follows:

4. (AMENDED) Device according to claim 1, in which an electrode of a fuel cell is separated from an adjacent passage or space for the supply of a working medium by a perforated plate (9), in which the size and/or density of the holes increases from a midline (13) to the edge and the mid-line runs parallel to the flow direction (14) of the working medium.

5. (AMENDED) Device according to claim 1, in which the size and/or density of the holes at the edge is at least about 5%, preferably about 20% greater than the size and/or density of the holes close to the midline.

6. (AMENDED) Method of operating a device with the features according to claim 1, in which the fuel cell stack is cooled externally by evaporation of a cooling medium in the adjacently-arranged cooling device, whereby the heat from the fuel cells is transferred to the cooling device mainly through thermal radiation.

REMARKS

The above preliminary amendment is made to remove multiple dependencies from claims 3, 4, 5, and 6. Please refer to the Marked-Up claim pages 11, and 13, attached herewith.

If a telephone conference would be helpful in resolving any issues concerning this communication, please contact Applicants' primary attorney-of record, John J. Gresens (Reg. No. 33,112), at (612) 371.5265.

Respectfully submitted,

MERCHANT & GOULD P.C.
Post Office Box 2903
Minneapolis, Minnesota 55402-0903
(612) 332-5300

Dated: March 1, 2002

By _____
John J. Gresens
Reg. No. 33,112

JJG/rw

MARKED UP VERSION

CLAIMS

1. A device with a fuel cell stack (1) and an external cooling device, so arranged that the heat from the fuel cells is transferred to the cooling device mainly by thermal radiation.

2. Device according to claim 1, in which the cooling device is formed from tubes (2), whereby the tubes are arranged in a supply space (7) or an exhaust space (3) for fuel.

-- CLAIM 1 --

3. Device according to [one of the preceding claims], in which the external cooling device and the fuel cell stack are arranged together in a housing.

-- CLAIM 1 --

4. Device according to [one of the preceding claims] in which an electrode of a fuel cell is separated from an adjacent passage or space for the supply of a working medium by a perforated plate (9), in which the size and/or density of the holes increases from a midline (13) to the edge and the mid-line runs parallel to the flow direction (14) of the working medium.

-- CLAIM 1 --

5. Device according to [one of the preceding claims], in which the size and/or density of the holes at the edge is at least about 5%, preferably about 20% greater than the size and/or density of the holes close to the midline.

-- CLAIM 1 --

6. Method of operating a device with the features according to [one of the preceding claims] in which the fuel cell stack is cooled externally by evaporation of a cooling medium in the adjacently-arranged cooling device, whereby the heat from the fuel cells is transferred to the cooling device mainly through thermal radiation.

I: **PRISCILLA MARY MAKOVSKI,** of 138 Hagley Road, Edgbaston, Birmingham, B16 9PW, do hereby declare that I am the translator of the documents attached of PCT application No. PCT/EP00/06450 and certify that the following is a true translation to the best of my knowledge and belief.

....

PRISCILLA MARY MAKOVSKI

Dated this 28th **day of** December **2001**

COOLING SYSTEM FOR FUEL CELLS

The invention relates to a fuel cell stack, in which several fuel cells are mechanically and electrically connected together.

Fuel cells are known from DE 44 30 958 C1 as well as from DE 195 31 852 C1, which have a cathode, an electrolyte and an anode. A passage or space adjacent the cathode is supplied with oxidation medium (for example air) and a passage or space adjacent the anode is supplied with fuel (for example hydrogen).

It is understood from DE 197 90 15 256 A1 that a distribution structure is provided in the above-mentioned passages or spaces. The distribution structures are of comb-like shape. This is to cause an even distribution of the working medium in each space.

The working medium reaches as far as the electrodes and is depleted there. Subsequently the depleted working medium flows out again, and is directed out of the fuel cell.

At the cathode of the known high temperature fuel cell of DE 44 30 958 A1, anions are formed in the presence of the oxidation means. The anions pass through the solid electrolyte and recombine on the anode side with hydrogen coming from the fuel, to make water. The recombination will liberate electrons and so produce electrical energy. The working temperature of a high temperature fuel cell is typically about 800°C.

At the anode of the known fuel cell of DE 195 31 852 C1 protons are formed in the presence of the fuel by means of a catalyst. The protons pass through the membrane (electrolyte) and combine on the cathode side with oxygen coming from the oxidation medium, to make water. Electrons will

be liberated at the anode and consumed at the cathode, so that electrical energy is produced.

In order to achieve good efficiency, the working medium must be distributed evenly in three dimensions in the fuel cell.

The flow of the working medium in the fuel cell must be such as to avoid or nearly to prevent pressure loss. Loss of pressure leads to loss of performance.

In an electrode space of a fuel cell (the space in which the electrode is located) there is, as a rule, a mixture of gases and/or liquids. The combustion gases can be diluted by inert gases. Through reforming and oxidation, a fuel such as a methanol-water mixture can also have a further inert gas such as carbon dioxide present in the relevant electrode space. The cathode will be supplied regularly with air and thereby also with the inert gas nitrogen.

The gases or liquids found at each electrode may be homogeneously mixed together, in order to help performance.

If unhumidified gases, that is, humidified gases not separated in a humidification device, are introduced into a polymer electrolyte membrane fuel cell, the electrode surfaces will be particularly evenly supplied with the working medium. Otherwise, the threat of a local drying up of an electrode and even an electrolyte membrane is increased. Local drying up results in performance loss and can be the cause of damage. The existence of a temperature gradient can cause local overheating of the fuel cell. Local drying-up can then result.

The exhaust flow of the working medium parallel to the electrodes over a lengthy region increases its exhaustion. Accordingly, the exhaust flow

reactions are quantitively distinguished, dependent on their location. The result is the appearance of a temperature gradient in a fuel cell.

Thermal gradients are in general to be avoided, as they can result in damage and reduced efficiency, so that the working temperature cannot be maintained at its optimum.

Accordingly, German patent application No. 198 08 331.9-45 has proposed, to solve the above-mentioned problem, the provision of a plurality of supply passages and adjacent exhaust flow passages. These passages have holes, adjacent to the electrodes of the fuel cell. The working medium flows through the holes at right angles to the electrode as well as the interface between the electrolyte and the electrode. In the same way, the outflow is also at right angles to these.

The holes are furthermore of different sizes, to obtain an even distribution of the gases along the electrode surfaces.

The above-described construction is disadvantageous because the plurality of passages is relatively expensive. The desired intermixing is also rather low.

In particular, the low intermixing is a disadvantage because of the appearance of local temperature gradients resulting from the reactions. A temperature differential causes low efficiency, because the working temperature locally differs from the optimum temperature.

The construction also the disadvantage that the separate supply and exhaust passages basically result in a halving of the areas, over which the working medium in the fuel cell or a stack of fuel cells flows. This disadvantage can in fact be balanced by a higher throughput. However, a higher throughput results in a greater pressure loss, and thereby lower efficiency.

The same applies to the areas, over which the depleted working medium flows out of the fuel cell or the fuel cell stack.

In fact, in a fuel cell the path between the separate supply and exhaust passages can be made very small in order to achieve enlarged entry and exit areas. However, this results in a worsening of the electrical contact between the fuel cells of a fuel cell stack and thereby reduced efficiency. A fuel cell stack is made up of several fuel cells, which are mechanically and electrically connected together by connecting elements.

According to a further German patent application, DE 198 53 911.8-45, it has been proposed to separate the electrodes of a fuel cell by a perforated plate in a passage or space adjacent the flat surfaces of the electrode. By a perforated plate is meant a flat member provided with holes. This plate is arranged parallel to the layers of the fuel cell (electrode and electrolyte layers). The corresponding working medium is supplied and exhausted through the adjacent space or passage. The holes in the plate are of macroscopic size, so that they are visible to the naked eye.

In the flow direction of the gases the density and/or the diameter of the holes in particular increase. This results in equal distribution, which leads to electrochemical reactions in the fuel cell being uniformly distributed. The existence of a temperature gradient can therefore be counteracted. In this arrangement the exhaust gas flow is the same as the supply gas flow.

The gases pass through the holes to the adjacent electrode. The gases flow out again uniformly indirectly through a neighbouring hole. In comparison with a fuel cell with separate supply and exhaust passages this achieves stronger intermixing (by swirling). Temperature gradients can therefore be avoided.

In particular in fuel cells which are subject to internal reforming or oxidation reactions, temperature gradients are present. The very rapid reforming reaction is limited in the usual fuel cells to a region of a few millimetres. The reaction is strongly endothermic. Thereby in a particular case of internal reforming, there is large intermixing which has the advantage of increasing the efficiency.

In the above-described implementation, a plurality of divided passages is avoided. The constructional expense is therefore small. It is only necessary to provide, for example, a perforated metal sheet between a connecting element of the fuel cell and the adjacent electrode.

In order to avoid temperature gradients in a fuel cell stack, it has further been proposed to cool a fuel cell by evaporation of a liquid cooling medium. The cooling medium either evaporates in the fuel cell stack, or it is supplied to a cooling device, which is arranged externally and at a distance from the fuel cell stack.

In the above-mentioned state of the art, it is an aim of the invention to provide a fuel cell or a fuel cell stack, in which the temperature distribution in the fuel cell is further improved. The aim of the invention is also the provision of a method for the particularly efficient working of the fuel cell or the fuel cell stack according to the claims.

The aim of the invention is achieved by a device with the features of claim 1. A method of operating the device is shown in the features of the secondary claim. The subsidiary claims describe advantageous developments.

According to the claims, the aim is achieved by a fuel cell stack, which is provided with an external and adjacent cooling device, through which a cooling medium flows. The cooling device is arranged close to the fuel

cell stack and constructed so that the heat from the fuel cell stack is mainly transferred through thermal radiation from the fuel cell stack to the cooling line and the cooling medium, thus causing cooling of the fuel cell. The cooling is controlled so that the cooling medium is evaporated by the heat which is removed.

In comparison with the state of the art with the external or internal cooling by evaporation, the claimed construction is simple and inexpensive. In the above-mentioned mode of operation (cooling by evaporation) uniform cooling takes place, so that the temperature of the cooling medium remains constant.

It will be understood that an externally-arranged cooling device means one that is not integrated with the fuel cell stack. An external form of cooling can be compared cooling through endothermic chemical reactions (for example methane reforming reaction in an external plate heat exchanger according to DE 19716438 A1), but cooling by evaporation is preferred. It will be understood by the term evaporation cooling, that a medium is evaporated by heat absorption.

Preferably water is used as the evaporating medium.

On the basis of the external cooling operation by heating up media (gases, liquids), which do not go through a phase change, it appears that the temperature gradients in the fuel cell or in the fuel cell stack increase. An increase in the cooling temperature of the cooling medium accordingly varies the cooling operation. A corresponding temperature gradient appears in the fuel cell or the fuel cell stack.

This undesired effect can be prevented, by cooling through evaporation. The temperature of the cooling medium hardly changes at all. The

corresponding cooling performance remains constant. Temperature gradients in the fuel cell or the fuel cell stack are therefore reduced.

The above-mentioned device operates in particular, so that at least 80%, and preferably at least 90%, of the heat given off by thermal radiation from the fuel cell is used for evaporation of the cooling medium. This form of heat transfer is simple and inexpensive in comparison with the heat transfer in the state of the art, in which a cooling medium is transported from the fuel cell to an external evaporator.

The operation of the fuel cell is arranged in particular so that heating of the cooling medium to boiling point or overheating of the evaporating liquid (evaporating cooling medium) does not take place.

In an advantageous development of the invention the fuel cell stack and the cooling device are arranged in a container. In this way a closed system is provided, which is protected from external disturbing influences. The operation of the device is therefore secured to a certain extent.

In a further advantageous development of the invention tubes acting as an evaporator are arranged in a casing or housing with the fuel cell stack. The cooling medium flows through the tubes. The tubes are arranged so that the fuel flows round them, as it enters and/or leaves the fuel cell or the fuel cell stack.

The cooling devices may be arranged horizontally and/or vertically in one or more of the gas supply spaces. By gas supply space will be understood a space arranged adjacent to the fuel cell or fuel cell stack, which supplies the working medium. Near the cooling device it acts preferably as a tube. Evaporating water is preferably used as the cooling medium, whose thermodynamic state is characterised by its wet steam region. Pre-heating to boiling point or overheating of the cooling medium, for example, water,

can therefore not result, and thereby energy must be used in an avoidable way.

Advantageously, the cooling device, which is in particular developed as the evaporator is placed on the longer side of a fuel cell stack with a rectangular plan, as here the greatest flat surface is available. The heat transfer is then particularly large. The working medium comes in and goes out of the fuel cell stack on these longer sides, so that it will flow round these cooling devices, at least partially. The cooling devices, for example the tubes, are preferably made of metal.

The problem can furthermore be solved, in that a fuel cell electrode is separated from the flat surface of the electrode adjacent the passage or space by a perforated plate. A perforated plate is a flat element provided with holes. It is arranged parallel to the layers of the fuel cell (electrodes and electrolyte layers). The corresponding working medium will flow into and out of the adjacent space or passage. The holes or openings in the plate are of macroscopic size, visible to the naked eye.

The holes in the plate which are arranged at the edge of the plate relative to a mid-line of the plate are more densely arranged and/or larger than the holes which are closer to or at the mid-line. The perforated plate thus borders an anode space, so that the flow direction of the fuel runs parallel to the mid-line.

More working medium reaches the adjacent anode space through the larger openings in the perforated plate than through the smaller openings. The working medium will be converted electrochemically in the anode space. Heat is thereby generated. The more working medium that is converted, the greater is the resulting quantity of heat. Thus, by the provision of the claimed perforated plate less heat will be produced in the interior of an anode space than at the edge, because the larger holes allow a greater

quantity of working medium to flow into the anode space. This edge of the anode space is situated in the region of the outer surface of a fuel cell or a fuel cell stack. The outer surface of a fuel cell or a fuel cell stack, through cooler surroundings, will be more strongly cooled than the interior of the fuel cell or the fuel cell stack. A temperature gradient in a fuel cell or in a fuel cell stack will thereby be avoided, bringing about a greater exothermic electrochemical consumption of the fuel adjacent the outer surface in comparison with an exothermic electrochemical consumption into the interior of the fuel cell or the fuel cell stack.

Gases also pass through the holes to the adjacent electrode. The gases flow out evenly and indirectly through an adjacent hole. The outflow, in comparison with a fuel cell with separate inlet and exhaust passages, is more greatly intermixed (by swirling). Temperature gradients are thus further avoided.

The constructional expense is small. It is only necessary for example to provide a perforated metal sheet between a connecting element of a fuel cell and the adjacent electrode.

The openings or holes in the perforated plate can be formed as desired. It is only necessary to ensure that the area of the passages in the above-mentioned edge region is greater than the area of the passages close to or at the above-mentioned mid-line. By area of the passages is to be understood the area through which the working medium flows through the perforated plate. It represents thus a sum of the areas of the holes in the claimed plate.

In an advantageous development of the invention the holes in the perforated plate are arranged symmetrically about the mid-line. Such a symmetrical distribution is partly responsible for the avoidance of temperature gradients.

The area of the passages at the edge region may be at least 5%, advantageously at least 20%, greater than the area of the passages close to the mid-line.

In a further advantageous development of the invention, the area of the passages through which a working medium flows through the perforated plate is increased in the flow direction to at least 10%, and preferably at least 100%. Such an increase in the flow direction is described in German Patent Application No. 198 53 911.8-45. This provision of the increased area of the passages will achieve, in addition to the above-mentioned operation, inflow of a working medium, not already in the inlet region completely into the corresponding electrode space. Thus, the continuing chemical reaction is not concentrated at the inlet region. In this way the avoidance of temperature gradients is further achieved.

The perforated plate is preferably made of a high-alloy, high-temperature steel (for example: X8 CrNiMoNb 16 16) or an electrically conducting ceramic (for example: La(Sr, Ca)$Cr0_3$). Such materials are suitable in particular for use in a high temperature fuel cell as they are high-temperature and corrosion resistant.

In a further advantageous development of the invention the claimed plate is formed as a perforated metal sheet, which is welded to the connecting element (known as a bipolar plate or interconnector) in a fuel cell stack.

The anode spaces of the individual fuel cells are provided with the perforated plate in the above-mentioned manner in the interior of a fuel cell stack.

The perforated plates are made in particular of metal.

The operation of the perforated plate in a fuel cell stack is achieved independently of the evaporation cooling.

The operating temperature can be maintained approximately constant by optimisation of the follow parameters:

1. The distance between the evaporator tubes and the fuel cell stack
2. The number of evaporator tubes
3. The length to width relationship of the plan of a fuel cell stack
4. The dimensions of the area of the passages in the perforated plate.

The skilled person will be able to ascertain the optimal parameters by a few trials.

The invention as illustrated in the Figures will now be further described.

Figure 1 shows a horizontal section through a fuel cell unit

Figure 2 shows a plan view of a perforated plate with symmetrically arranged openings.

Figure 1 shows in section a fuel cell stack, consisting of several fuel cells 1. The fuel cells are coupled together electrically and mechanically by connecting elements. Tubes 2 are adjacent to the longer sides of the fuel cell stack. The tubes 2 are shown in cross-section. Cooling medium is conducted through these tubes. The tubes are arranged in an exhaust gas space 3 as well as in an anode gas supply space 7. Separating walls 4 seal in a gas tight manner the anode gas supply space 7, the cathode supply space 5 and the anode gas exhaust space 3 as well as the cathode gas exhaust space 11 from each other. The anode side working medium 8 and the cathode side working medium 6 run perpendicular to each other and are connected by lines 10 to the supply spaces and the exhaust spaces. The

tubes 2 are preferably arranged in the anode gas supply space, because in the event of leakage from the tubes, the water vapour released is electrochemically harmless on the anode side. The assumption here is that water is used as the cooling medium. The fuel 8 passes next through a perforated plate 9, before it reaches the anode. One realisation of the perforated plate is illustrated in Figure 2. The holes 12 are arranged symmetrically to the left-hand and right-hand sides of a mid-line 13. The diameter of the holes 12 increases with increasing distance from the mid-line. The arrows 14 indicate the flow direction of the anode gas.

CLAIMS

1. A device with a fuel cell stack (1) and an external cooling device, so arranged that the heat from the fuel cells is transferred to the cooling device mainly by thermal radiation.

2. Device according to claim 1, in which the cooling device is formed from tubes (2), whereby the tubes are arranged in a supply space (7) or an exhaust space (3) for fuel.

3. Device according to one of the preceding claims, in which the external cooling device and the fuel cell stack are arranged together in a housing.

4. Device according to one of the preceding claims, in which an electrode of a fuel cell is separated from an adjacent passage or space for the supply of a working medium by a perforated plate (9), in which the size and/or density of the holes increases from a midline (13) to the edge and the mid-line runs parallel to the flow direction (14) of the working medium.

5. Device according to one of the preceding claims, in which the size and/or density of the holes at the edge is at least about 5%, preferably about 20% greater than the size and/or density of the holes close to the midline.

6. Method of operating a device with the features according to one of the preceding claims, in which the fuel cell stack is cooled externally by evaporation of a cooling medium in the adjacently-arranged cooling device, whereby the heat from the fuel cells is transferred to the cooling device mainly through thermal radiation.

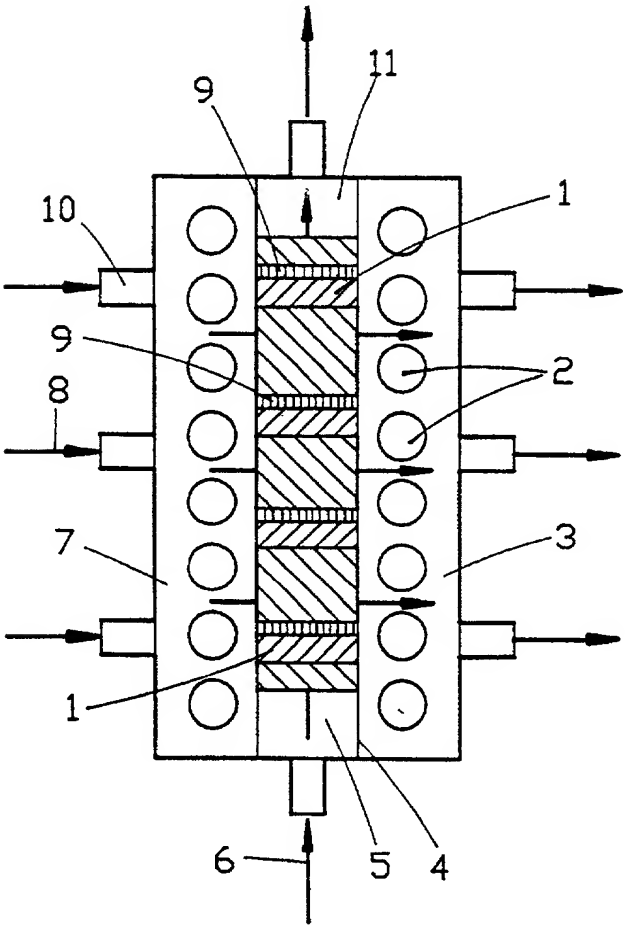

FIG.1

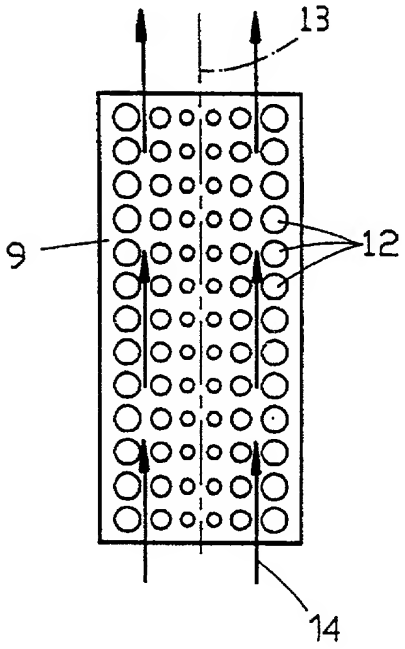

FIG.2

G 61730

Attorney Docket No. 616.99USWO

MERCHANT & GOULD P.C.

United States Patent Application

COMBINED DECLARATION AND POWER OF ATTORNEY

As a below named inventor I hereby declare that: my residence, post office address and citizenship are as stated below next to my name; that

I verily believe I am the original, first and sole inventor (if only one name is listed below) or a joint inventor (if plural inventors are named below) of the subject matter which is claimed and for which a patent is sought on the invention entitled: COOLING SYSTEM FOR FUEL CELLS

The specification of which
a. ☒ is attached hereto
b. ☒ was filed on _____ as application serial no. _____ and was amended on ____ (if applicable) (in the case of a PCT-filed application) described and claimed in international no. PCT/EP00/06450 filed July 7, 2000 and as amended on _____ (if any), which I have reviewed and for which I solicit a United States patent.

I hereby state that I have reviewed and understand the contents of the above-identified specification, including the claims, as amended by any amendment referred to above.

I hereby claim foreign priority benefits under Title 35, United States Code, § 119/365 of any foreign application(s) for patent or inventor's certificate listed below and have also identified below any foreign application for patent or inventor's certificate having a filing date before that of the application on the basis of which priority is claimed:

a. ☐ no such applications have been filed.
b. ☒ such applications have been filed as follows:

FOREIGN APPLICATION(S), IF ANY, CLAIMING PRIORITY UNDER 35 USC § 119			
COUNTRY	**APPLICATION NUMBER**	**DATE OF FILING (day, month, year)**	**DATE OF ISSUE (day, month, year)**
GERMANY	19935719.6	29/JULY/1999	
ALL FOREIGN APPLICATION(S), IF ANY, FILED BEFORE THE PRIORITY APPLICATION(S)			
COUNTRY	**APPLICATION NUMBER**	**DATE OF FILING (day, month, year)**	**DATE OF ISSUE (day, month, year)**

I hereby claim the benefit under Title 35, United States Code, § 120/365 of any United States and PCT international application(s) listed below and, insofar as the subject matter of each of the claims of this application is not disclosed in the prior United States application in the manner provided by the first paragraph of Title 35, United States Code, § 112, I acknowledge the duty to disclose material information as defined in Title 37, Code of Federal Regulations, § 1.56(a) which occurred between the filing date of the prior application and the national or PCT international filing date of this application.

U.S. APPLICATION NUMBER	DATE OF FILING (day, month, year)	STATUS (patented, pending, abandoned)

I hereby claim the benefit under Title 35, United States Code § 119(e) of any United States provisional application(s) listed below:

U.S. PROVISIONAL APPLICATION NUMBER	DATE OF FILING (Day, Month, Year)

I acknowledge the duty to disclose information that is material to the patentability of this application in accordance with Title 37, Code of Federal Regulations, § 1.56 (reprinted below):

§ 1.56 Duty to disclose information material to patentability.

(a) A patent by its very nature is affected with a public interest. The public interest is best served, and the most effective patent examination occurs when, at the time an application is being examined, the Office is aware of and evaluates the teachings of all information material to patentability. Each individual associated with the filing and prosecution of a patent application has a duty of candor and good faith in dealing with the Office, which includes a duty to disclose to the Office all information known to that individual to be material to patentability as defined in this section. The duty to disclose information exists with respect to each pending claim until the claim is canceled or withdrawn from consideration, or the application becomes abandoned. Information material to the patentability of a claim that is canceled or withdrawn from consideration need not be submitted if the information is not material to the patentability of any claim remaining under consideration in the application. There is no duty to submit information which is not material to the patentability of any existing claim. The duty to disclose all information known to be material to patentability is deemed to be satisfied if all information known to be material to patentability of any claim issued in a patent was cited by the Office or submitted to the Office in the manner prescribed by §§ 1.97(b)-(d) and 1.98. However, no patent will be granted on an application in connection with which fraud on the Office was practiced or attempted or the duty of disclosure was violated through bad faith or intentional misconduct. The Office encourages applicants to carefully examine:

(1) prior art cited in search reports of a foreign patent office in a counterpart application, and

(2) the closest information over which individuals associated with the filing or prosecution of a patent application believe any pending claim patentably defines, to make sure that any material information contained therein is disclosed to the Office.

(b) Under this section, information is material to patentability when it is not cumulative to information already of record or being made of record in the application, and

(1) It establishes, by itself or in combination with other information, a prima facie case of unpatentability of a claim; or

(2) It refutes, or is inconsistent with, a position the applicant takes in:

(i) Opposing an argument of unpatentability relied on by the Office, or

(ii) Asserting an argument of patentability.

A prima facie case of unpatentability is established when the information compels a conclusion that a claim is unpatentable under the preponderance of evidence, burden-of-proof standard, giving each term in the claim its broadest reasonable construction consistent with the specification, and before any consideration is given to evidence which may be submitted in an attempt to establish a contrary conclusion of patentability.

(c) Individuals associated with the filing or prosecution of a patent application within the meaning of this section are:

(1) Each inventor named in the application:

(2) Each attorney or agent who prepares or prosecutes the application; and

(3) Every other person who is substantively involved in the preparation or prosecution of the application and who is associated with the inventor, with the assignee or with anyone to whom there is an obligation to assign the application.

(d) Individuals other than the attorney, agent or inventor may comply with this section by disclosing information to the attorney, agent, or inventor.

(e) In any continuation-in-part application, the duty under this section includes the duty to disclose to the Office all information known to the person to be material to patentability, as defined in paragraph (b) of this section, which became available between the filing date of the prior application and the national or PCT international filing date of the continuation-in-part application.

I hereby appoint the following attorney(s) and/or patent agent(s) to prosecute this application and to transact all business in the Patent and Trademark Office connected herewith:

Albrecht, John W.	Reg. No. 40,481	Leonard, Christopher J.	Reg. No. 41,940
Ali, M. Jeffer	Reg. No. 46,359	Liepa, Mara E.	Reg. No. 40,066
Altera, Allan G.	Reg. No. 40,274	Lindquist, Timothy A.	Reg. No. 40,701
Anderson, Gregg I.	Reg. No. 28,828	Lown, Jean A.	Reg. No. 48,428
Batzli, Brian H.	Reg. No. 32,960	Mayfield, Denise L.	Reg. No. 33,732
Beard, John L.	Reg. No. 27,612	McDonald, Daniel W.	Reg. No. 32,044
Berns, John M.	Reg. No. 43,496	McIntyre, Jr., William F.	Reg. No. 44,921
Branch, John W.	Reg. No. 41,633	Mitchem, M. Todd	Reg. No. 40,731
Brown, Jeffrey C.	Reg. No. 41,643	Mueller, Douglas P.	Reg. No. 30,300
Bruess, Steven C.	Reg. No. 34,130	Nelson, Anna M.	Reg. No. 48,935
Byrne, Linda M.	Reg. No. 32,404	Paley, Kenneth B.	Reg. No. 38,989
Campbell, Keith	Reg. No. 46,597	Parsons, Nancy J.	Reg. No. 40,364
Carlson, Alan G.	Reg. No. 25,959	Pauly, Daniel M.	Reg. No. 40,123
Caspers, Philip P.	Reg. No. 33,227	Phillips, John B.	Reg. No. 37,206
Clifford, John A.	Reg. No. 30,247	Pino, Mark J.	Reg. No. 43,858
Cook, Jeffrey	Reg. No. 48,649	Prendergast, Paul	Reg. No. 46,068
Daignault, Ronald A.	Reg. No. 25,968	Pytel, Melissa J.	Reg. No. 41,512
Daley, Dennis R.	Reg. No. 34,994	Qualey, Terry	Reg. No. 25,148
Daulton, Julie R.	Reg. No. 36,414	Reich, John C.	Reg. No. 37,703
DeVries Smith, Katherine M.	Reg. No. 42,157	Reiland, Earl D.	Reg. No. 25,767
DiPietro, Mark J.	Reg. No. 28,707	Samuels, Lisa A.	Reg. No. 43,080
Doscotch, Matthew A.	Reg No. P-48,957	Schmaltz, David G.	Reg. No. 39,828
Edell, Robert T.	Reg. No. 20,187	Schuman, Mark D.	Reg. No. 31,197
Epp Ryan, Sandra	Reg. No. 39,667	Schumann, Michael D.	Reg. No. 30,422
Glance, Robert J.	Reg. No. 40,620	Scull, Timothy B.	Reg. No. 42,137
Goff, Jared S.	Reg. No. 44,716	Sebald, Gregory A.	Reg. No. 33,280
Goggin, Matthew J.	Reg. No. 44,125	Skoog, Mark T.	Reg. No. 40,178
Golla, Charles E.	Reg. No. 26,896	Spellman, Steven J.	Reg. No. 45,124
Gorman, Alan G.	Reg. No. 38,472	Stewart, Alan R.	Reg. No. 47,974
Gould, John D.	Reg. No. 18,223	Stoll-DeBell, Kirstin L.	Reg. No. 43,164
Gregson, Richard	Reg. No. 41,804	Sullivan, Timothy	Reg. No. 47,981
Gresens, John J.	Reg. No. 33,112	Sumner, John P.	Reg. No. 29,114
Hamer, Samuel A.	Reg. No. 46,754	Swenson, Erik G.	Reg. No. 45,147
Hamre, Curtis B.	Reg. No. 29,165	Tellekson, David K.	Reg. No. 32,314
Harrison, Kevin C.	Reg. No. 46,759	Trembath, Jon R.	Reg. No. 38,344
Hertzberg, Brett A.	Reg. No. 42,660	Tunheim, Marcia A.	Reg. No. 42,189
Hillson, Randall A.	Reg. No. 31,838	Underhill, Albert L.	Reg. No. 27,403
Holzer, Jr., Richard J.	Reg. No. 42,668	Vandenburgh, J. Derek	Reg. No. 32,179
Hope, Leonard J.	Reg. No. 44,774	Wahl, John R.	Reg. No. 33,044
Jardine, John S.	Reg. No. P-48,835	Weaver, Paul L.	Reg. No. 48,640
Johns, Nicholas P.	Reg. No. 48,995	Welter, Paul A.	Reg. No. 20,890
Johnston, Scott W.	Reg. No. 39,721	Whipps, Brian	Reg. No. 43,261
Kadievitch, Natalie D.	Reg. No. 34,196	Whitaker, John E.	Reg. No. 42,222
Kaseburg, Frederick A.	Reg. No. 47,695	Wier, David D.	Reg. No. P-48,229
Kettelberger, Denise	Reg. No. 33,924	Williams, Douglas J.	Reg. No. 27,054
Keys, Jeramie J.	Reg. No. 42,724	Withers, James D.	Reg. No. 40,376
Knearl, Homer L.	Reg. No. 21,197	Witt, Jonelle	Reg. No. 41,980
Kowalchyk, Alan W.	Reg. No. 31,535	Wong, Thomas S.	Reg. No. 48,577
Kowalchyk, Katherine M.	Reg. No. 36,848	Wu, Tong	Reg. No. 43,361
Lacy, Paul E.	Reg. No. 38,946	Young, Thomas	Reg. No. 25,796
Larson, James A.	Reg. No. 40,443	Zeuli, Anthony R.	Reg. No. 45,255

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I hereby authorize them to act and rely on instructions from and communicate directly with the person/assignee/attorney/firm/ organization who/which first sends/sent this case to them and by whom/which I hereby declare that I have consented after full disclosure to be represented unless/until I instruct Merchant & Gould P.C. to the contrary.

I understand that the execution of this document, and the grant of a power of attorney, does not in itself establish an attorney-client relationship between the undersigned and the law firm Merchant & Gould P.C., or any of its attorneys.

Please direct all correspondence in this case to Merchant & Gould P.C. at the address indicated below:

Merchant & Gould P.C.
P.O. Box 2903
Minneapolis, MN 55402-0903

23552
PATENT TRADEMARK OFFICE

I hereby declare that all statements made herein of my own knowledge are true and that all statements made on information and belief are believed to be true; and further that these statements were made with the knowledge that willful false statements and the like so made are punishable by fine or imprisonment, or both, under Section 1001 of Title 18 of the United States Code and that such willful false statements may jeopardize the validity of the application or any patent issued thereon.

2	**Full Name Of Inventor**	**Family Name** THOM	**First Given Name** Frank	**Second Given Name**
0	**Residence & Citizenship**	**City** Duren	**State or Foreign Country** GERMANY	**Country of Citizenship** GERMANY DEK
1	**Mailing Address**	**Address** Kopernikusstrasse 25	**City** Düren	**State & Zip Code/Country** 52353 GERMANY

Signature of Inventor 201: 03/02/02 F. Thom **Date:** 03.02.02